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Romanian Academy Iaşi Branch Geography Team | Alexandru Ioan Cuza University of Iaşi Faculty of Geography and Geology Department of Geography

SOIL SURVEY AND MAPPING USING QGIS IN THE SPECIFIC METHODOLOGICAL CONTEXT OF ROMANIA

Bogdan Roşca[a*], Radu Pîrnău[b], Mihai Niculiţă[b], Iuliana Niculiţă[b],

[a]Romanian Academy, Department of Iasi - Geography Group,
[b]Department of Geography, Faculty of Geography and Geology
Al.I. Cuza University of Iasi

Abstract

The purpose of this paper is to describe the use of QGIS as tool for soil survey and mapping in Romanian methodological context and to analyze the efficiency of Open Source tools in this matter. Beginning with integrating data from various sources (GPS points, analog and digital maps, analytical soil data, etc), continuing with editing and spatial analysis and finishing with map production, we have used QGIS and it's add-ons in every stage of the soil survey and mapping process following, as much as possible, standard procedures specified by methodology. Also we have searched for optimal solution in order to solve specific problems that may occur such as the type of topology for digitization (when the surveyor need to create data from scratch), how to integrate various databases, specific queries, etc. In conclusion QGIS, with his vast array of tools, can successfully be used in soil survey and for map production according to standards required by Romanian methodology. It can be implemented also very easily with minimum effort both technical and financial.

Keywords: QGIS, Open Source, spatial tools, soil survey, mapping,

1. INTRODUCTION

Soil survey and mapping is a joint effort which requires both field and bureau work for gathering, analyze, interpreting and disseminating soil data. The result of this effort usually contains numerous maps and diagrams produced by interrogating the soil database created previously. All this approach is very large consumer of both human and financial resources. One of major expanses is purchasing and maintenance of specialized software for database creation and map production. Open source GIS can be a viable solution for reducing these costs, that being the main reason for this study. In a previous work (Roşca et al., 2012) we compare four open source GIS software in order to identify the most stable and complete solution for soil survey and the conclusion was that QGIS is the best candidate.

QGIS is an open source application which has the most extended GIS capabilities. Is a mature platform (QGIS Development Team, 2012), highly configurable and extendable through

Corresponding author:
**e-mail address:* roscao@gmail.com

Python which can interact verry well with other applications such as GRASS, R, SAGA etc. From the entire QGIS suite we have choose to test only the Mobile and Desktop components.

The main goal in this study is to create a complete Soil Information System (SIS) by using these two components of QGIS and the data available following the framework ilustrated in Figure 1 and based on it, to produce maps and diagrams.

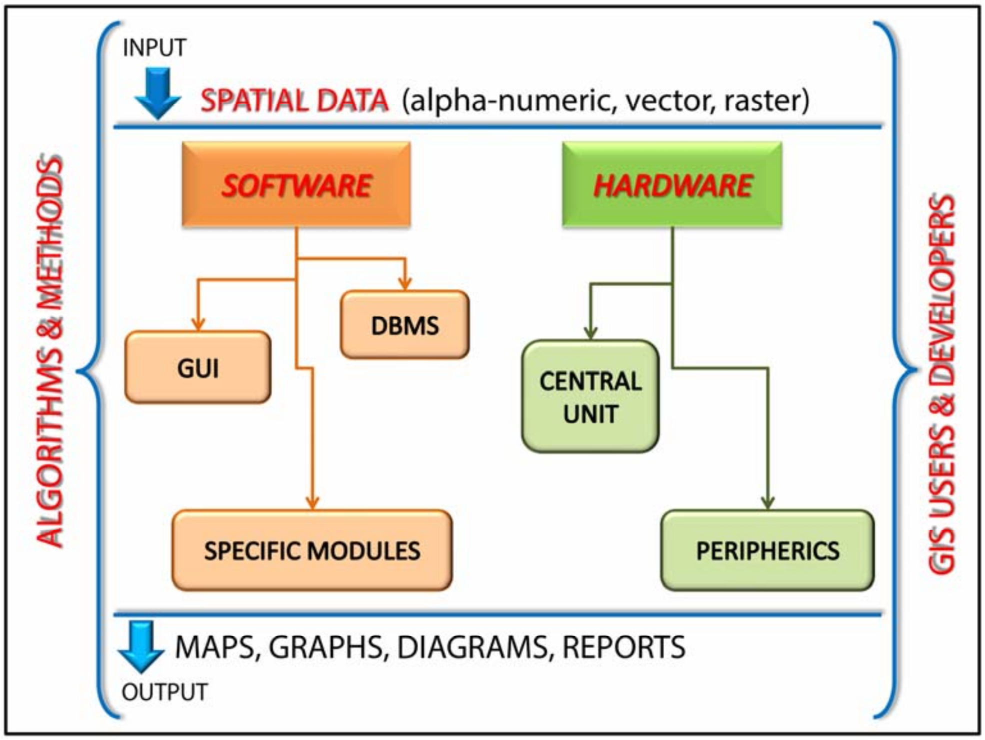

Figure 1. A general framework for creating a Soil Information System

Soil Information Systems (SIS) are special GIS, capable of storing, manipulating and analyzing soil-terrain data (Rossiter 2004, Lagacherie and McBratney, 2007). The population of SIS with soil information it is done by Digital Soil Mapping (DSM) and it is sustained by the digital modeling, covariates and ancillary data.

2. MATERIALS AND METHODS

The soil data used for testing the capabilities of QGIS and the associated packages where collected in several field campaigns and where analyzed in OJSPA Iasi laboratories. In several stages of the testing process auxiliary data consisting in altitude values (DEM), climatic variables, land use, etc., where used to produce various layers or information which were added to soil database or used in soil quality evaluation. The existing ancillary data consisting in old soil analyses and maps where used also, both for testing the software and for completing the database.

Four aspects were taken into account in order to test the software capabilities:

- Data acquisition
- Data storage

- Data manipulation and analysis
- Data dissemination

For each of these aspects, specific tasks were design in order to cover the needs of a soil surveyor. In this respect, we prepare small data sets, representative for each task and we have installed additional packages such as R, SAGA or OTB. In order to create auxiliary data illustrating terrain features, climatic parameters or land use, we have used the GRASS modules implemented in QGIS through SEXTANTE add-on. Terrain parameters were produced by using DEM at 10 meters resolution interpolated with *v.suf.rst* module. With the exception of landforms layer, all the other parameters representing slope values, aspect, curvatures and hypsometry, climatic and hydrologic variables, were created using the available QGIS add-ons. The landform layer was created with *r.geomorphon* module from GRASS 7.0 which is not yet integrated with QGIS but the data can be imported through GDAL.

3. RESULTS AND DISCUSSION

Data acquisition

At this stage we have tested the mobile component of QGIS in the field for data capture and management. Although it is still in development, QGIS Mobile can be a very useful tool being able not only to register a certain feature, for example a soil profile, but to attach various parameters to it, such as surrounding terrain characteristics, soil attributes, etc. and by doing so to populate the database. In general QGIS Mobile works well but it is still buggy and it is only for ANDROID devices.

Another aspect of data acquisition that we have tested is the georeference options and vector editing capabilities. In QGIS the *Georeferencer* module works in both ways: can add control points to a map or can capture coordinate from a background map (Figure 2) procedure needed especially for ancillary data represented by blueprints of soil maps without coordinates or projection grid but with recognizable features (roads intersections, cadastral limits, etc).

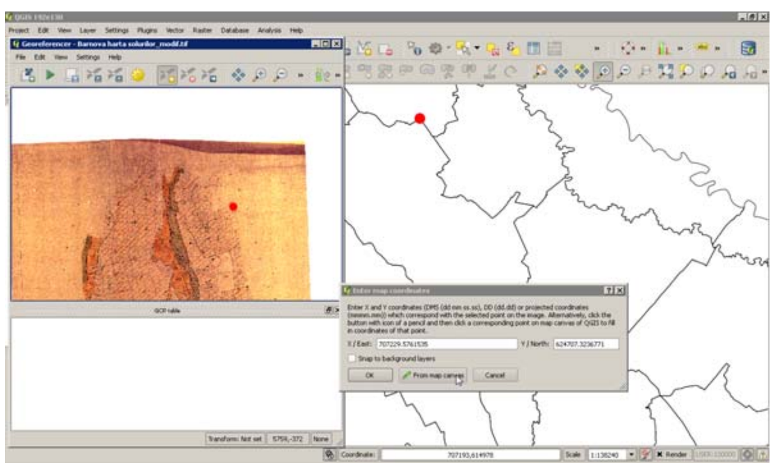

Figure 2. Georeferencing the soil map (left) by capturing control points from cadastral limit (right).

Vector editing capabilities were tested in two ways: creating new features by interpreting the soil data collected (classic approach for soil maps) and digitizing existing soil maps in raster format

(procedure applied for integrating ancillary data). One important aspect is that QGIS offer multiple choices for vector editing: shapefile topology in which the user can create only one type of feature or mixed topology, specific to GRASS package, where two types of elements can coexist (a line and a polygon). This last type of topology is very useful when the soil surveyor creates a map from scratch. The development version of QGIS (1.9) contain a new procedure called *topological editing* which provide less work on adjacent polygons than previous version where this procedure was done by an addon called *polygonizer*. There is though, a lack of automatic digitizing tool such as trace capabilities, feature that can save a lot of time, especially in the case of ancillary data.

Data storage

In QGIS data can be stored in most supported geospatial data formats (shapefile, GeoTiff) or (preferable) in spatial databases:

- SQLite for mobile version
- PostGreSQL + PostGIS or SpatiaLite (but also proprietary databases) for desktop version

QGIS have full support for web services (WMS, WCS, WFS), but also loads Google, Bing, OpenStreetMap and MapQuest tiles (trough a plugin), usable as background layers from which the soil scientists can interpret soil-terrain conditions.

Using the terrain and analytical soil profile data we have created a working soil database using PostGreSQL that had been used for producing soil maps and for evaluation of soil quality.

Data manipulation and analysis

Due to the integration of various external modules (SAGA, OTB) through SEXTANTE or GRASS add-ons, QGIS offer a wide array of spatial analyses. We have tested these capabilities first by producing the DEM and second by deriving various parameters (slope, aspect, terrain features). A special case of integration that was tested using the soil database previously created was between SEXTANTE and R. A simple example of statistical analysis using R in QGIS is illustrated in Figure 3 where we adapt a script for extracting histograms of various soil parameters.

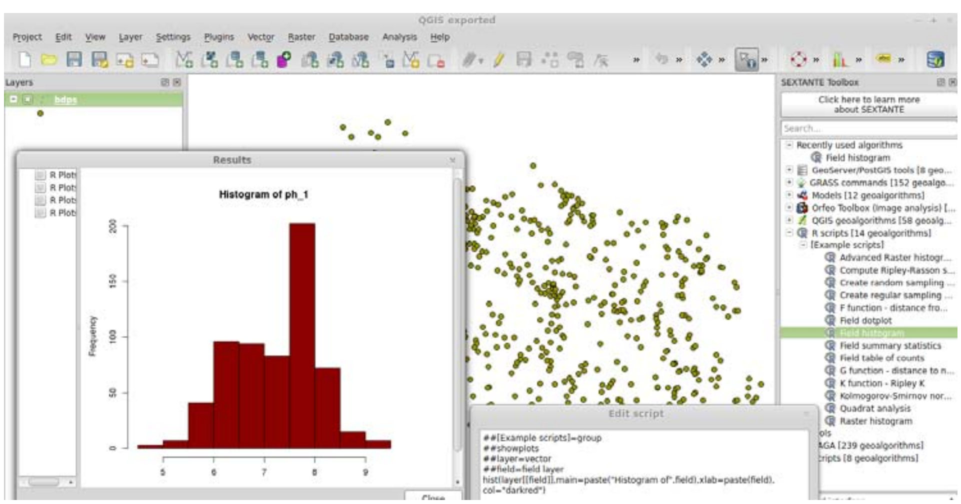

Figure 3. Basic statistical analysis with R through SEXTANTE

By using R directly in QGIS, a more complex quantitative and qualitative analyses can be performed on soil database, with results that can be easily integrated in the final report as diagrams representing various properties such as vertical variation of properties or profile characteristics (Figure 4).

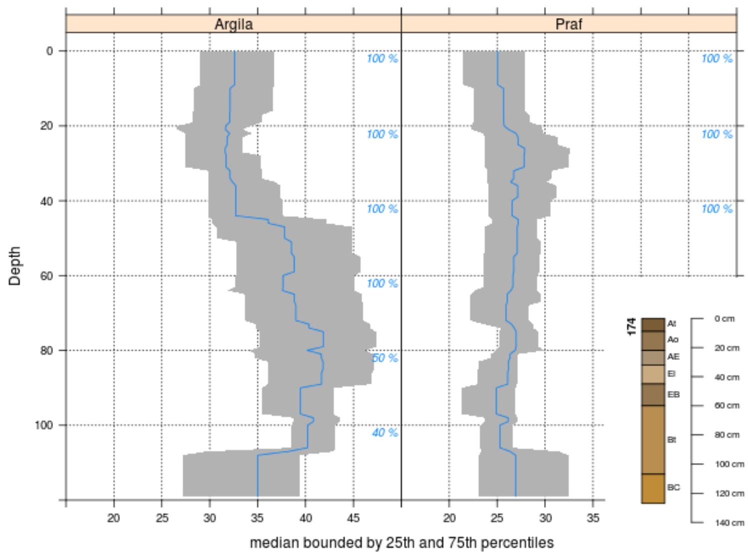

Figure 4. Complex example of soil database analysis with R in QGIS

All this capabilities can be extended easily using Python for creating plugins to serve for specific needs. One of this plugins was created for land evaluation process in respect of Romanian Soil Methodology. The plugin integrates three major databases into a single one: Agricultural Land Evaluation Database witch through SQL interrogations produce numerous maps, tables, charts and reports. The process imply first to create the Soil database which contain *soil profile database* and *soil units database,* each of these with specific information related to soil characteristics (soil profile attributes, US properties, soil types, coordinates, etc.). Second stage consists in creating the Cartographic Unit Database which contains spatial layers with soil units, Ecologically Homogenous Territory units and land suitability units. The third stage is the creation of Terrain Database with terrain attributes, climatic parameters, hydrological variables, etc. Each of these databases is related and all together form Agricultural Land Evaluation Database (Figure 5). This plugin can be used in decisions making regarding soil quality management and for agricultural exploitation planning.

Data dissemination

QGIS have implemented a fully developed cartographic module designed for producing professional maps. New version has numerous novelties implemented in Map Composer such as ruled base labeling, rulers and guide lines or "alignments", map grids, HTML labels, etc. As a result of these new capabilities and using the soil database previously created, a soil map was produced following the available cartographic standards regarding soil colors (Figure 6). Beside maps, using various modules implemented in R, one can generate reports automatically (knitr, latex) and integrate them directly into various documents.

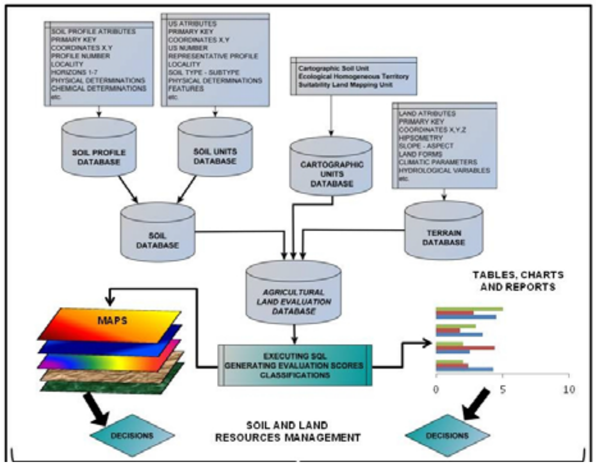

Figure 5. Data flow and structure of the process of agricultural land evaluation implemented through QGIS - SIS

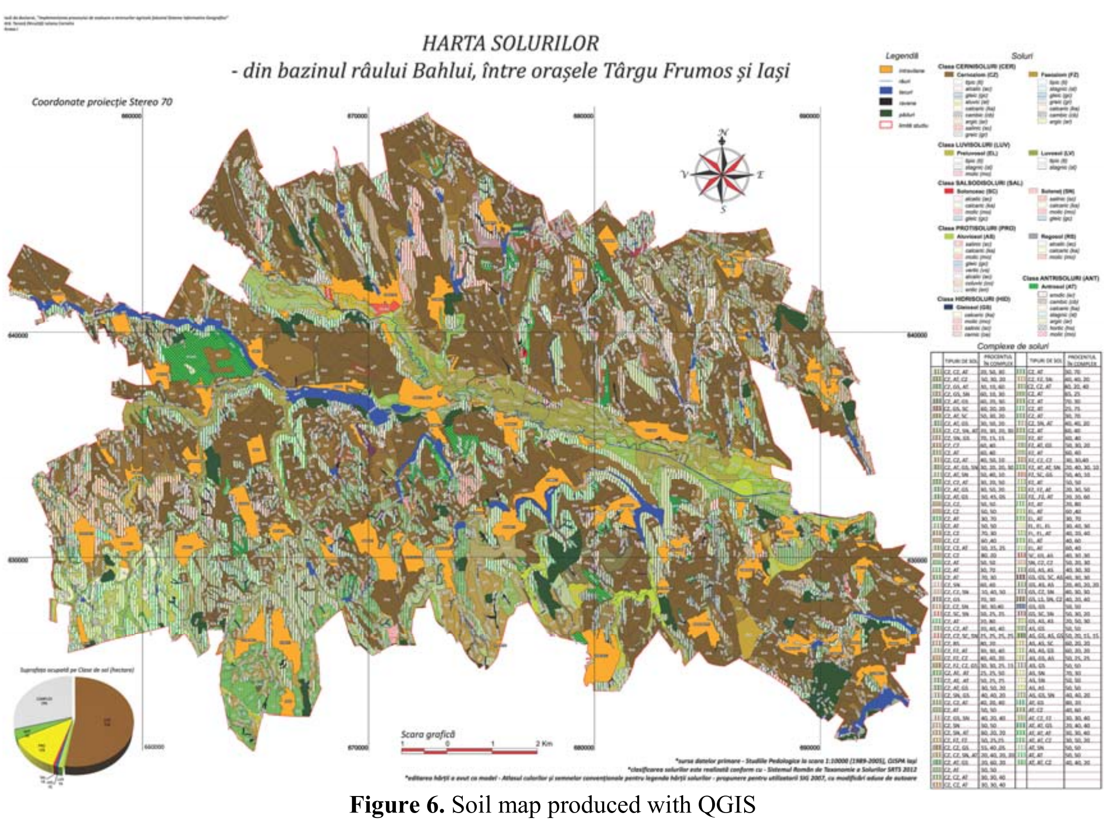

Figure 6. Soil map produced with QGIS

4. CONCLUSIONS

Analyzing all four stages of testing the application we can conclude that QGIS constitutes a viable and sustainable solution for creating and manage a Soil Information System. It contains all the tools needed for collecting and process the soil data, for creating complex spatial databases and for designing and publish professional looking maps. Being open source, it can be easily implemented, configured and extended to suit specific needs of soil surveying. Also the costs are substantially reduced; the only expenses implied being for hardware, initial implementation and training.

It has also some disadvantages derived also from being developed by an open community. It requires specialized expertise for integration with various external packages, especially when it is implemented on proprietary operating systems. Also it needs numerous auxiliary applications to be installed process that can create confusion.

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